FINAL TECHNICAL REPORT

INFRARED SPECTROSCOPY OF JUPITER AND SATURN

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Roger F. Knacke

Division of Science
Penn State Erie
Station Road
Erie, PA 16563-0203

Phone: (814) 898-6105
FAX: (814) 898-6213
RFK2@PSUVM.PSU.EDU

Strategy

Infrared spectroscopy provides unique insights into the chemistry and dynamics of the atmospheres of Jupiter and Saturn -- and of Titan, the enigmatic satellite of Saturn. The 5 micron spectral region of these objects is transparent to deep levels, and is therefore particularly useful for the identification of molecules in the deep atmosphere at very low (parts per billion) concentrations. In Titan, 5 micron observations probe atmospheric layers at or near the surface. The observations support and complement VOYAGER and CASSINI measurements. Ground-based spectroscopy is sensitive to lower mixing ratios for selected molecules, while the spacecraft mass and infrared spectrometers probe molecules that are inaccessible from the ground. The ground-based observations also provide time-based data for preparation for the CASSINI mission.

Accomplishments

In 1991 we obtained data at J, H, K, and M and made repeated observations of Titan's albedo as the satellite orbited Saturn. The J albedo is 12+-3% greater than the albedo measured in 1979; the H and K albedos are the same. There was no evidence for variations at any wavelength over the eastern half of Titan's orbit. We also obtained low resolution (R = 50) spectra of Titan between 3.1 and 5.1 microns. The spectra contain evidence for CO and CH_3D absorptions. Spectra of Callisto and Ganymede in the 4.5 micron spectral region are featureless and give albedos of 0.08 and 0.04 respectively. If Titan's atmosphere is transparent near 5 microns, its surface albedo there is similar to Callisto's. These results were summarized in two papers by Noll and Knacke (1992, 1993; Appendix).

In 1992 and 1993 we obtained further spectroscopic data of Titan with the UKIRT CGS4 spectrometer. We discovered two unexpected and unexplained spectral features in the 3-4 micron spectrum of Titan. An apparent emission feature near the 3 micron (nu_3) band of methane indicates temperatures higher than known to be present in Titan's upper stratosphere and may be caused by unexpected non-LTE emission. An absorption feature near 3.47 microns may be caused by absorption in solid grains or aerosol's in Titan's clouds. The feature is similar, but not identical to organics in the interstellar matter and in comets.

Anticipated Work Beyond the Termination of the Grant

We are currently preparing the latest Titan results for publication. The new results will be followed up with further observations at the UKIRT and the IRTF telescopes. During the course of the present grant we also prepared a plan for new observation of CO and other rare constituents in Jupiter and Saturn. The work will initially consist of spatially resolved observations of the disk of Jupiter with the IRTF's CSHELL spectrometer. We expect to get spectra of at least 50 regions across Jupiter's disk. This unparalled spatial (and frequency) resolution should allow us to make significant progress in understanding the origins of trace

compounds and their chemistry in Jupiter. If the Jovian observations are successful, we plan to follow with observations of Saturn.

At the time that this observing program was defined, we learned of the impending Shoemaker - Levy comet impact on Jupiter. We will participate in the campaign to observe this event, concentrating on spectroscopy of Jupiter before, during and after the collisions.

These planned observations are funded under a separate grant through NASA's Solar System Exploration Division, Office of Space Science and applications.

Inventions

There were no inventions completed under this grant.

Publications

Noll, K.S. and Knacke, R.F., 1992, "Titans Mid-IR Albedo: New Observations from 3 to 5 microns," in Proceedings Symposium on Titan, ESA SP-338.

--- 1993, "Titan: 1-5 micron Photometry and Spectrophotometry and a Search for Variability," Icarus, 101, 272.